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A RADIATIVE TRANSFER BASED APPROACH TO MERGE SMOS AND AMSR-E SOIL MOISTURE INTO ONE CONSISTENT RECORD

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Abstract —Recently, a study funded by the European Space Agency (ESA), the SMOS Fusion project, was set up to provide guidelines for the development of a global soil moisture climate record with a special emphasis on the integration of SMOS. Three different data fusion approaches were designed and implemented on 10 year passive microwave data (2003-2013) from two different satellite sensors; the ESA Soil Moisture Ocean Salinity Mission (SMOS) and the NASA/JAXA Advanced Scanning Microwave Radiometer (AMSRE).

This study is part of the Fusion project and investigates a radiative transfer based based approach to merge AMSRE and SMOS soil moisture retrievals using the Land Parameter Retrieval Model (LPRM). LPRM has already been successfully applied to SMOS observations in earlier studies and now we will focus on the merging strategy with AMSR-E. The first step in this project is a small update on the roughness parameterization in the SMOS LPRM. Then the merging of the AMSRE and SMOS LPRM is done by optimizing the AMSRE LPRM to best match the SMOS LPRM in soil moisture dynamics followed by a linear merging of the two datasets. The resulting AMSRE LPRM soil moisture retrievals are compared against ERA-Land, MERRA-Land and the International Soil Moisture Network (ISMN).

1 Study plan

In an earlier study by Van der Schalie et al. (2015), it was shown that LPRM can be successfully applied to SMOS L-band observations, producing high quality soil moisture retrievals similar to SMOS Level 3 soil moisture, while using a single parameterization globally and minimizing the use of ancillary datasets on for example vegetation. They did show however, that for SMOS LPRM the bias was too wet over very dry areas like the Sahara, and too dry when the vegetation gets dense.

The first step addresses this issue by introducing an updated roughness parameterization which includes a vegetation correction, which deals with the known difficulty to disentangle vegetation and roughness influences in soil moisture retrievals.

Secondly, the AMSRE LPRM parameters for C- and X-band will be optimized to match the SMOS LPRM retrievals. This optimization is based on the parameterization of the single scattering albedo, roughness and polarization mixing factor for the overlapping period of the two sensors, July 2010 to October 2011.

Finally, the updated AMSRE LPRM will be linearly merged with the SMOS LPRM dataset. The final AMSRE LPRM dataset is then evaluated against MERRA-Land, ERA-Land and all available measurements from the International Soil Moisture Network over the period of 2003 to 2009.

2 Roughness update

The new empirical method to estimate the roughness contains a correction for vegetation influences without using external sources of information, by first calculating SMOS LPRM as in the previous version, and using its retrieved Vegetation Optical Depth in the second run to correct for the vegetation influences. This has minimal effect on the high correlations as gotten with the previous version and improves the absolute values. Mean retrievals shown in Fig 1.

New roughness formula: $h = h_1\,(A_v(1-2\theta) + B_v\,\tau_v)$

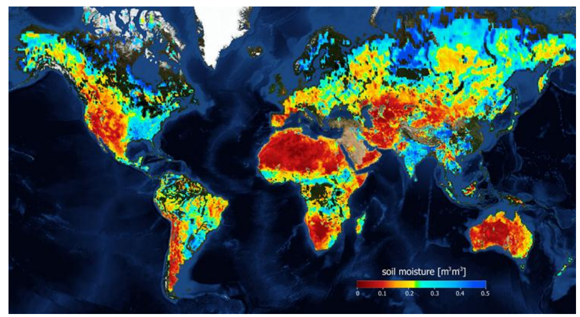

Fig. 1: Mean SMOS LPRM soil moisture after the improved roughness parameterization over the period of July 2010 to December 2013

3 Updated AMSRE LPRM

The AMSRE LPRM parameterization was updated for both the C-band and X-band frequencies and, in contrast to what it used to be, is now the same for both C- as X-band. The update includes a new roughness parameterization very similar to the one applied to SMOS LPRM and this is combined with an increase of the single scattering albedo from 0.05 and 0.06 to 0.075. These parameters were found during several optimization runs. This parameterization resulted in very high correlations between the AMSRE and SMOS LPRM products as can be seen in Fig 2. The updated soil moisture retrievals from AMSRE show very similar dynamics as that of SMOS LPRM over all areas that do not have dense vegetation or sandy deserts.

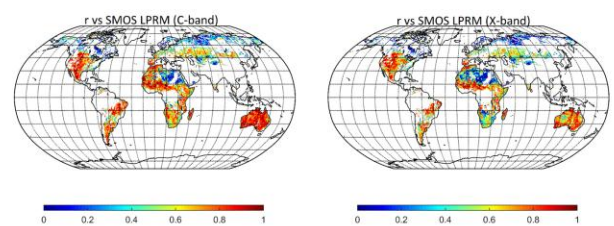

Fig. 2: Correlation coefficient of AMSRE LPRM vs SMOS LPRM using the updated parameterization

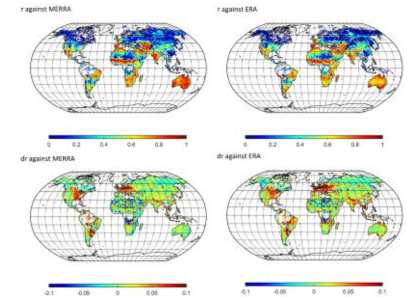

Fig. 3: Correlations of the updated C-band LPRM against MERRA-Land and ERA-Land

The long term dataset of AMSRE LPRM was tested for the period of 2003 to 2009 and compared against MERRA-Land and ERA-Land. Fig 3 shows the correlations that the new C-band AMSRE LPRM reaches against these two products. The results again show an overall good performance (>0.6) over all areas except for the densely vegetated, sandy desert and the boreal areas. Compared to the old method, the main places of improvement are the eastern part of the USA and Europe. For the unbiased root mean square error, the results are slightly improved compared to the old version, with an ubrmse < 0.10 everywhere except for the boreal areas. This is expected due to difficulties defining the effects and filtering of permafrost, snow, open water and vegetation in these areas.

In Fig 4 you see the performance of C-band AMSRE LPRM against the available 560 in situ stations of the ISMN. The mean r of 0.49, ubrmse of 0.084 and bias of -0.02 are all a slight improvement compared to the old LPRM version.

X-band retrievals against MERRA-Land, ERA-Land and the ISMN show a very similar behavior, only with a slightly higher noise level and quicker saturation over densely vegetated areas due to the higher frequency.

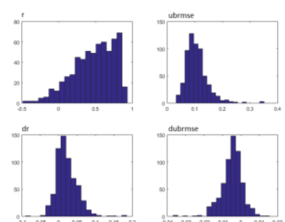

Fig. 4:Histograms of the comparison between C-band AMSRE LPRM and all the available ground observations from the international soil moisture network.

4 Conclusions

The results of this study show that the new roughness update for SMOS LPRM leads to a more natural distribution of soil moisture worldwide, while it keeps a similar high level of performance as before.

The update of AMSRE LPRM shows that the LPRM performs very similar for the different frequencies, leading to soil moisture retrievals that correlate very well with each other, modelled soil moisture from MERRA-Land and ERA-land and in situ measurements from the ISMN.

Acknowledgements

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